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As the official journal of the AIA Academy of Architecture for Health (AAH), this publication explores subjects of interest to AAH members and others involved in the fields of healthcare architecture, planning, design, and construction. The goal is to promote awareness, educational exchange, and advancement of the overall project-delivery process and building products.

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Neonatal Intensive Care Unit (NICU) Room Type Design Trends

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ABSTRACT

Since the first neonatal intensive care unit (NICU) in the world was established at the Yale-New Haven Hospital in 1960s, the number of NICUs has grown and the design has evolved. This study explores data regarding NICU room types and NICU room access to daylight.

An online survey was used that gathered information on: NICU hospital location, year of construction, numbers of rooms and beds per room, number of rooms with daylight and daylight sources. Subjects were recruited from a list of NICUs in the United States for which there was contact information. Eighty-eight medical directors completed the survey.

Based on the results, we conclude that the multiple-room configuration, which usually means an open-bay layout in NICU design, was the prominent room type before 1990. The average number of beds in NICUs with 2-3 beds per room is 2.71. The rapid expansion of SFRs and mixed SFRs, relative to 2-3 beds per room units since 1994 reveals the trend to reduce the number of beds per room and create a more individualized developmental care environment.

Regarding light, access to daylight via exterior windows is the most commonly used means. Existing SFR units have the advantage of providing more daylight than the other configurations; however, daylight is not a given in this configuration. The ratio of SFR rooms that have access to daylight is still lower than 85%, so the incorporation of daylight must be a design objective in and of itself.

ARTICLE

Neonatal Intensive Care Unit (NICU) Room Type Design Trends

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Introduction

Since the first neonatal intensive care unit (NICU) in the world was established at the Yale-New Haven Hospital in New Haven in 1965 (Historical Archives Advisory Committee, 2001), the number of NICUs has grown and the design has evolved. The demand for newborn intensive care has been increasing in the recent years; as a result, the number of NICU facilities in the United States expanded 20% from 1996 to 2011 (AAP, 1996, 2011) (see Figure 1). The physical environment of NICU departments has received more attention as well (Stevens et al., 2010). Several projects and studies emphasize the design trend of using private rooms instead of the traditional layout of open-bay rooms (Milford, Zapalo, & Davis, 2008; Feldman, 2009; Padbury, Van Vleet, & Lester, 2010; Bosch, Bledsoe, & Jenzarli, 2012).

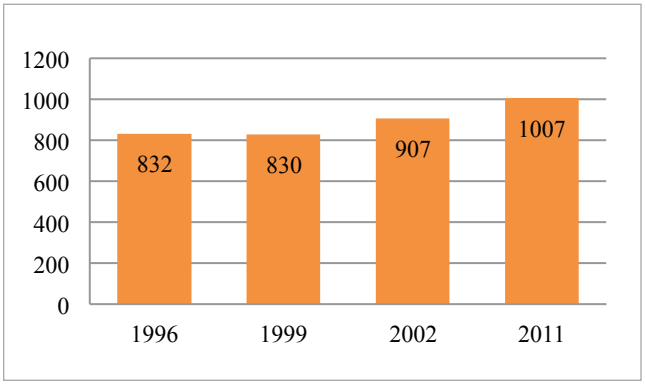


FIGURE 1: Number of NICU facilities in the United States, 1996–2011 (aap, 1996, 1999, 2002, 2011)

However, with the exception of the publication, *Design of Pediatric and Neonatal Critical Care* (Shepley, 2014), there has been little documentation of the transitions associated with different layouts in NICUs from either architectural design or medical facility perspectives. Another issue that has not been addressed is the historical role of natural light in NICUs. Although researchers have yet to demonstrate benefits of access to light for infants before 28 weeks of gestation, the importance of natural light in infant development and daily activities afterwards has been documented (e.g., Vandenberg, 2007; Rizzo, Rea, & White, 2010; Graven, 2011; White, R. D., Smith, J. A., & Shepley, M. M., 2013) and may have had a bearing on NICU design development. This paper addresses how NICU room types have changed over the last 50 years and when the change initially happened.

Method

This study explores two aspects of NICU rooms: one is data regarding NICU room types; the other is date regarding NICU room access to daylight and daylighting models.

An online survey was used for this investigation. The survey *NICU Room Type & Lighting Condition Questionnaire* collected (1) NICU physical environment information, such as the hospital location, built or renovated year, numbers of rooms and beds in each of the three room types (single family room (SFR), 2–3 baby beds per room, and more than 3 beds per room), and numbers of rooms with each type of daylighting condition (by exterior windows, by interior windows with daylight from exterior windows, by skylight and three combinations of any two types) and (2) staff evaluations regarding electric lighting and daylighting in NICUs. Figures 2 and 3 illustrated the typical floor plans of SFR and multiple-bed rooms. The questions regarding the physical environment were yes-no question or fill-in-the-blank; questions asking about subjective opinions were based on a seven-point Likert-scale.

The questionnaire was created using the online survey platform *Qualtrics*. The link to it was emailed to the nationwide NICU medical directors identified in *Newborn Intensive Care Units (NICUs) and Neonatologists of the USA & Canada Directory* (AAP, 2011) during March, 2014. Two reminder emails were sent

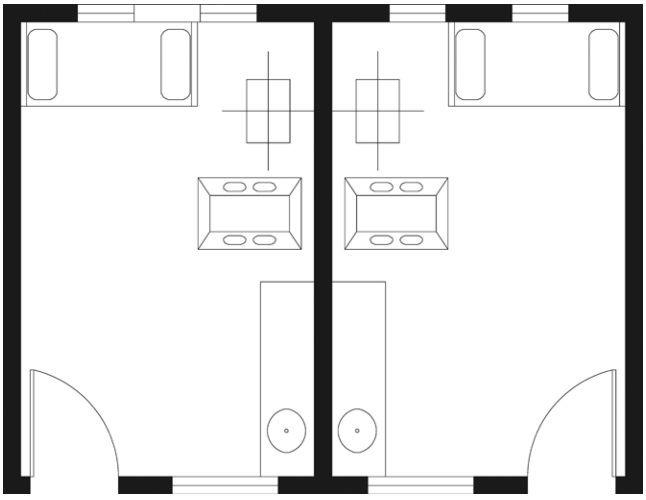


FIGURE 2: Typical floor plan of SFR NICU

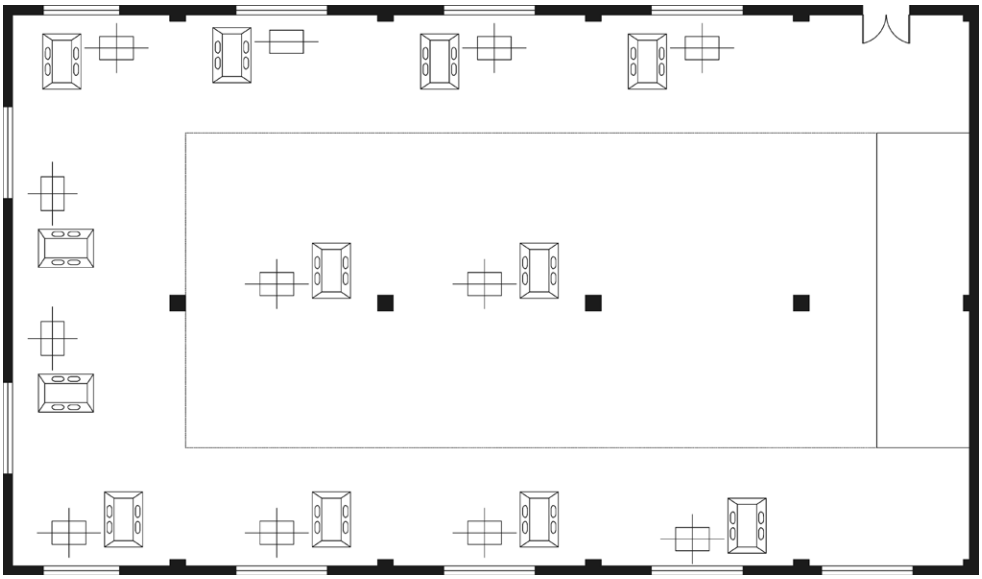


FIGURE 3: Typical floor plan of multiple-bed NICU rooms

FIGURE 4: The states covered by the returned questionnaires

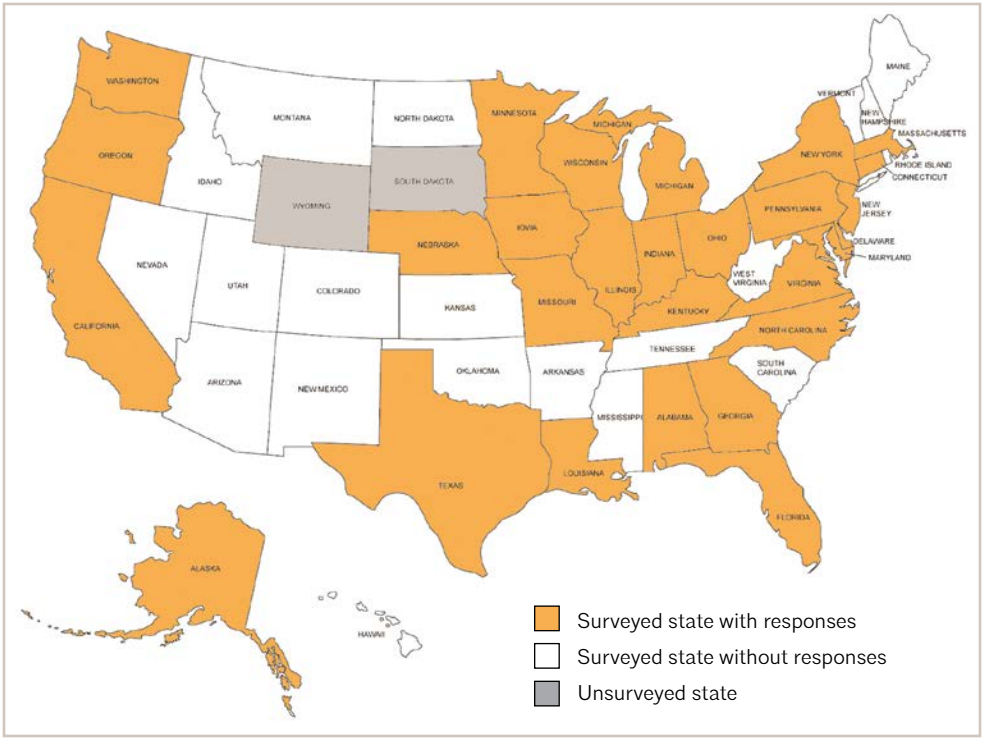
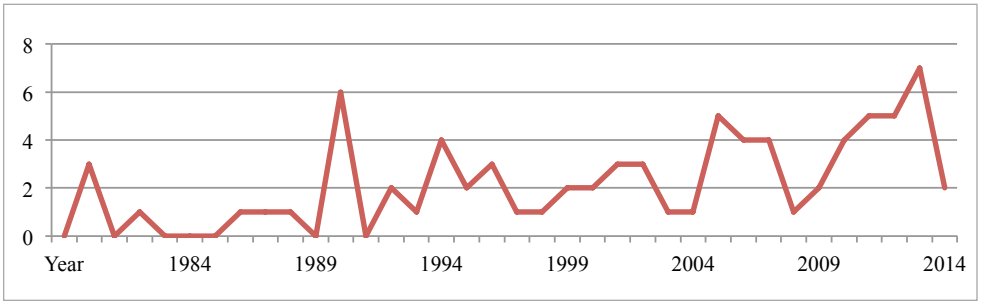


FIGURE 5: Number of NICU facilities by most recent year built or renovated



to enhance the return rate. The entire data collection process lasted for about 50 days to allow the medical directors enough time to respond. The study was approved by the Texas A&M University Institutional Review Board.

Results

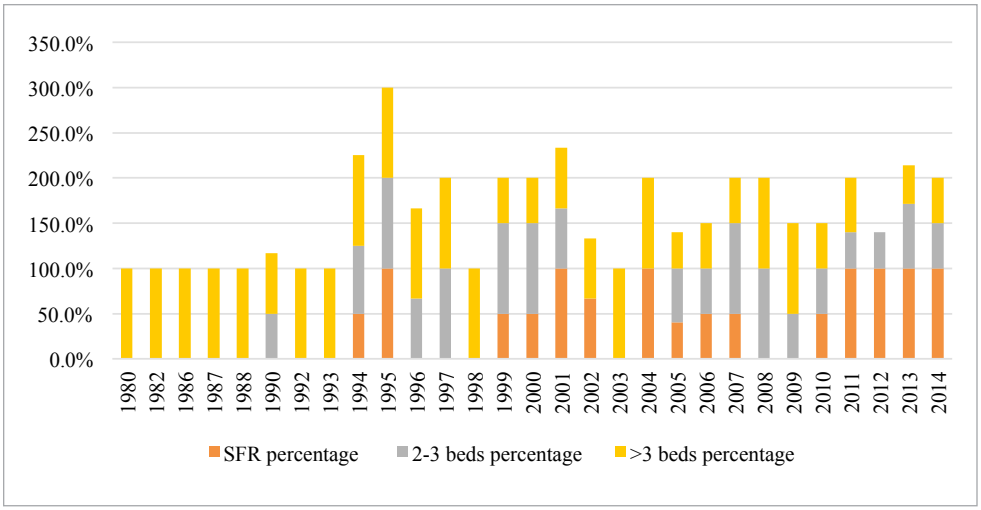
The directory listed a total of 1,007 NICUs in the United States. Excluding seven hospitals in Puerto Rico and one naval hospital in Okinawa, Japan, information was provided for 589 out of 999 NICUs regarding the medical directors' email contact information. Four hundred and eighty-two of these were effective email addresses. Ninety-seven medical directors opened the link to the online survey and agreed to participate, and 89 among them finished the survey. If all the 482 medical directors with effective email address actually saw the invitation email, then the response rate was 20.1% (97/482), and the completion response rate was 18.5% (89/482).

The questionnaires were distributed to 49 states (which excluded Wyoming that, according to the Directory (AAP, 2011), did not have a hospital with an NICU and South Dakota which did not have an effective medical director email address). The 88 returned questionnaires covered 29 states (see Figure 4). For the NICUs that had been rebuilt or renovated, the most recent year of construction was used for the analysis.

The key findings from the survey responses regarding bed distribution were as follows:

- The most recently built or renovated NICUs spanned from 1980 until 2014 (see Figure 5). There was no SFR unit until 1994 and 2-3 beds per room units did not appear until as late as 1990. Figure 6 shows the

Figure 6: Occupation percentages of different NICU room types in hospitals by most recent year built or renovated



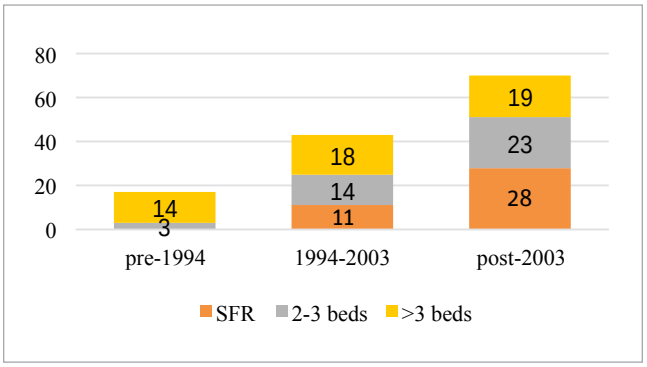


FIGURE 7: Number of hospitals by NICU room type by most recently built or renovated time period

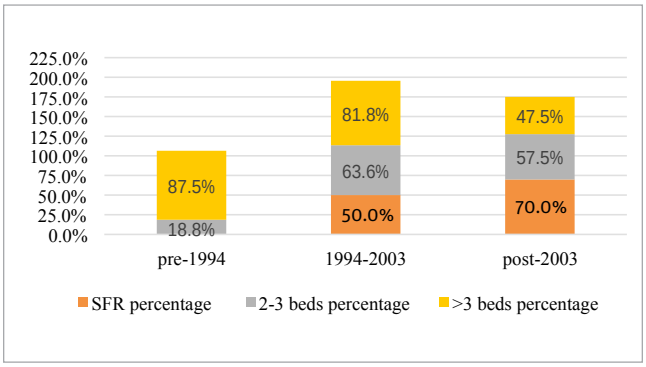
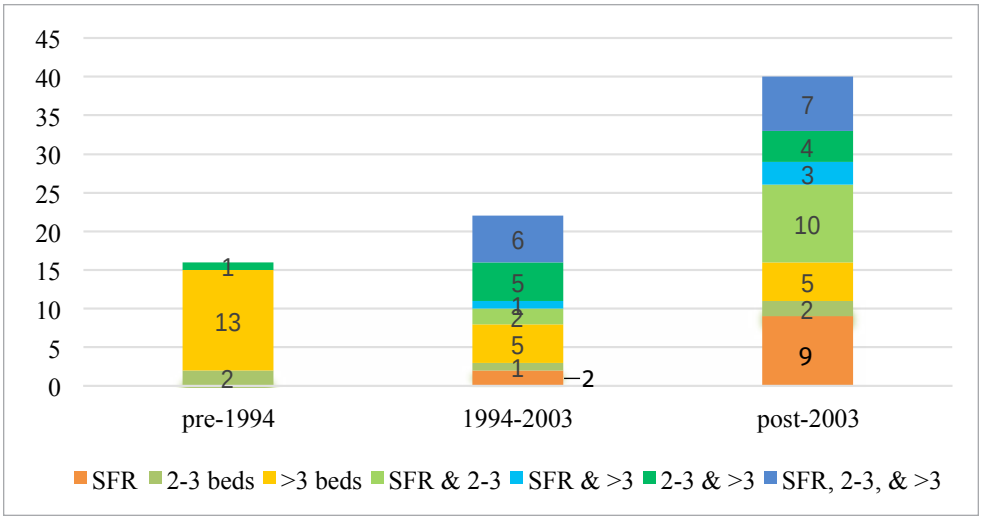


Figure 8: Occupation percentages of different NICU room types in hospitals by most recent built or renovated time period

proportion of NICU numbers in each room type out of the hospital numbers with NICUs. The totals exceed 100% due to units that have multiple types of rooms.

- If divided years into the periods of pre-1994, 1994-2003, and post-2003, as shown in Figure 7, we found the number of newly built/renovated NICUs with more than 3 beds to be relatively stable; however, the SFR units and the NICUs with 2-3 beds per room increased dramatically.
- Taking into account the co-existence of different room types in the same NICU, we calculated the proportion of NICUs in each room type relative to the hospital numbers with NICUs during each period. The results are shown in Figure 8. As in Figure 6, the totals exceed 100% due to units that have multiple types of rooms. We found that after the large increase (almost double) of mixed types during 1994 to 2003 compared to pre-1994, the use of mixed types in the same NICU decrease after 2003.
- Before 1994, the NICU room types were either 2–3 beds per room or more than 3 beds per room with the exception of one hospital with two room types. Since the SFR appeared, the mixed room types are various. If comparing the latter two periods, SFR and the mixed use of SFR and 2–3 beds per room are the fastest increasing while other types are stable (see Figure 9).
- The inner circle in Figure 10 shows the distribution of mixed and non-mixed NICU room types in hospitals, while the outer circle illustrates the specific distribution of each type. On the average, there are 2.71 beds per room for units with 2–3 beds per room and 6.89 beds per room for units with more than 3 beds per room.

FIGURE 9: Number of hospitals with mixed and non-mixed NICU room types by most recently built or renovated time period



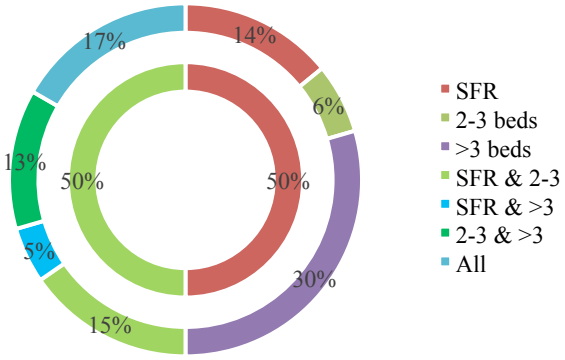


FIGURE 10: Distribution of hospitals with mixed and non-mixed NICU room types

The key findings from the survey responses regarding daylighting were as follows:

- Not all rooms in NICUs have access to daylighting even in the same NICU department. SFRs, however, have greater access; 58.5% of SFRs have all rooms access to daylight while less than a half of the 2-3 beds per room units have access and even less for units with more than 3 beds per room (see Table 1).
- The utilization of different daylighting models in NICUs is shown in Table 2. The majority of those rooms with daylight receive lighting directly from the exterior wall, but 40.1% have rooms with access to daylight via interior windows (including combination with other types).
- SFRs commonly have some rooms with access to daylight via exterior windows and some via interior windows. For the other two types, access to daylight both by exterior and interior windows is the second most common model.

Discussion

Based on these results, we conclude that the multiple-room configuration, which usually means an open-bay layout in NICU design, is the prominent room type before 1990. The construction of SFR units has increased since the unit was built mid-1990s and has subsequently increased in popularity.

We notice that the average number of beds in NICUs with 2–3 beds per room is 2.71. If we categorize

the rooms into single, double, and multiple patient rooms, this type is closer to multiple-bed configurations. That also explains the low utilization of 2–3 beds per room and mixed types of 2–3 beds per room relative to 3+ beds per room configuration. The rapid expansion of SFRs and mixed SFRs and 2–3 beds per room units reveals the trend to reduce the number of beds per room and create a more personal care environment.

Regarding light, access to daylight via exterior windows is the most commonly used means. Existing SFR units have the advantage of providing more daylight than the other configurations; however, daylight is not a given. The ratio of beds of SFR rooms that have access to daylight is still lower than 85%, so the incorporation of daylight must be a design objective in and of itself.

Study limitations

There are three potential limitations to this study. Firstly, the limited number of responses may results in lack of ability to generalize the date to NICUs nationwide. Secondly, while medical directors are familiar with their NICU departments, they are not the designers of these facilities. When they report on the NICU physical environment, they may have different concepts and definitions of the room types and the lighting models. Thirdly, the questions listed in the survey are only a small part of the topic; and the response options might not cover all the possibilities. The room design is more complex than the short multiple-choice/fill-in-blank questionnaire could summarize.

Conclusion

Since the first SFR was built during mid-1990s, the overall trend has been to reduce the number of beds per room and enhance individualized and developmental care. Providing more rooms with access to daylight will need to be an additional focus of designers. As a life-defining place for infants, families, and caregivers (White, 2011), the NICU department requires continual improvement and research.

Acknowledgement

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TABLE 1: Basic conditions of NICUs access to daylighting

ROOM TYPE	AMOUNT	AVG. NUMBER OF BEDS/ ROOM	ALL ROOMS ACCESS TO DAYLIGHT	PERCENTAGE OF NICUS ACCESS TO DAYLIGHTING
SFR	41	1	24	58.5%
2–3 beds	41	2.71	18	43.9%
>3 beds	52	6.89	23	44.2%

TABLE 2: Distribution of daylighting models in NICUs by different room type

ROOM TYPE	EXTERIOR WINDOW	INTERIOR WINDOW	SOME EXTERIOR, SOME INTERIOR	BOTH EXTERIOR & INTERIOR	OTHER
SFR	20	6	11	6	2
2–3 beds	28	4	3	9	3
>3 beds	31	3	6	9	6
Total	**79**	**13**	**20**	**24**	**11**

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